Colloquium paper: bioenergetics, the origins of complexity, and the ascent of man.

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Public Summary:

Scientific Abstract:
Complex structures are generated and maintained through energy flux. Structures embody information, and biological information is stored in nucleic acids. The progressive increase in biological complexity over geologic time is thus the consequence of the information-generating power of energy flow plus the information-accumulating capacity of DNA, winnowed by natural selection. Consequently, the most important component of the biological environment is energy flow: the availability of calories and their use for growth, survival, and reproduction. Animals can exploit and adapt to available energy resources at three levels. They can evolve different anatomical forms through nuclear DNA (nDNA) mutations permitting exploitation of alternative energy reservoirs, resulting in new species. They can evolve modified bioenergetic physiologies within a species, primarily through the high mutation rate of mitochondrial DNA (mtDNA)-encoded bioenergetic genes, permitting adjustment to regional energetic environments. They can alter the epigenomic regulation of the thousands of dispersed bioenergetic genes via mitochondrially generated high-energy intermediates permitting individual accommodation to short-term environmental energetic fluctuations. Because medicine pertains to a single species, Homo sapiens, functional human variation often involves sequence changes in bioenergetic genes, most commonly mtDNA mutations, plus changes in the expression of bioenergetic genes mediated by the epigenome. Consequently, common nDNA polymorphisms in anatomical genes may represent only a fraction of the genetic variation associated with the common "complex" diseases, and the ascent of man has been the product of 3.5 billion years of information generation by energy flow, accumulated and preserved in DNA and edited by natural selection.

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